Free-roaming Domestic Cats and Wildlife:

Evaluating Impacts through Wildlife Rehabilitation Admissions

Kendra J. Carter

Undergraduate Honors Thesis

Advisor: Dr. Roger Williams

June 2, 2009

The Ohio State University

School of Environment and Natural Resources

Columbus, OH

In conjunction with the Ohio Wildlife Center

INTRODUCTION

The American Pet Products Manufacturing Association (2002) estimates there are nearly 100 million cats in the United States, 40-50% of which are stray or feral. Issues surrounding pet overpopulation are not limited to animal shelters and control agencies, however, because *Felis catus*, though domesticated, is recognized as an innate hunter. Though some disagree on why domestic cats hunt, little doubt remains that if a cat encounters prey, its predatory instinct will be triggered. As a result, free-roaming domestic cats (FRDC) are considered an introduced predator, and thus, *Felis catus* has entered the wildlife conservation debate.

While FRDC have clearly demonstrated their potential to significantly impact island and other isolated ecosystems, vigorous debate continues over FRDC impacts on mainland wildlife. Ecologists, wildlife biologists, animal rights advocates, and veterinarians are a few of the major players debating the breadth of, and management solutions for, this controversial issue.

The Ohio Wildlife Center (OWC), a non-profit wildlife rehabilitation organization, receives sick and injured wildlife from good-Samaritans throughout Ohio. Founded by Donald Burton, DVM, OWC is a full service rehabilitation center with the stated mission of "fostering an awareness and appreciation of Ohio's native wildlife through rehabilitation, education and wildlife health studies" (Ohio Wildlife Center, 2009). Nationally recognized as an authority on native Ohio wildlife issues, OWC receives approximately 5000 injured and orphaned animals representing over 130 different species annually (OWC, 2009). Dr. Burton and the staff of OWC have expressed concern over the growing numbers of cat-attack related admissions, and the impact they may be having on local wildlife.

LITERATURE REVIEW

The body of literature surrounding this issue illustrates the persistent intensity within debates over severity and types of FRDC impacts occurring, and reasonable and humane solutions to the associated problems. A 1988 publication titled *The Domestic Cat; the Biology of its Behavior* is an influential work cited throughout the literature, and is often used as the basis for many researchers' claims. Specifically, the chapter addressing the diet of domestic cats as it relates to their impact on prey populations is cited on a regular basis. Though this piece makes several appearances in the current body of literature, it is somewhat outdated and thus may not provide a perspective appropriate to current ecological conditions.

Review of FRDC-focused literature illuminates how gaps in knowledge combine with disagreement in study design and results, to create an intense research need. While not entirely cohesive, the literature is illustrative of the overall FRDC issue through discussions centering on *definitions, debate, knowledge and agreement,* and *calls for research*.

I. Definitions

A small source of conflict for FRDC issues lies at the fundamental level of *definition*. There are no universally accepted definitions of the various subcategories of FRDC, which poses problems when extrapolating results from studies that seek to determine the impacts of domestic cats on wildlife. Without such universal definitions, development of sound methodology for testing any hypotheses related to these cat populations proves difficult. If researchers don't clearly define their variables at a level acceptable to the research community, their studies are inherently flawed and thus easily questioned and countered by others. That said, Slater (2004) offers the following general definitions for the FRDC subcategories:

I. "free-roaming" – outdoors at least part of the time

II. "un-owned free-roaming" -

(a) stray/socialized – outside all of the time, comfortable with human presence/habitation

(b) feral/un-socialized – born outside, distrustful of humans, generally avoid human habitation

Both un-owned free-roaming categories (a and b) can be further divided into *subsidized* and *unsubsidized*, with subsidization referring to feeding and other care provided by humans.

II. The Debate

The literature certainly demonstrates that the issues surrounding FRDC are extraordinarily complex and varied. I describe 'the debate,' as represented in the literature, in terms of *perspectives and approaches*, and *conflicts* (*bias* and *viewpoints*).

- *Perspectives and Approaches*

According to Slater (2004), the *debate* over FRDC in general can be discussed according to three perspectives: 1) predation of native species by cats, 2) cats as a non-native species (and thus, to be excluded from the wild), and 3) cats as a domestic species for whom we are responsible for providing safety and confinement (for both their protection and that of wild species).

The *approaches* for management of FRDC can also be placed into three categories, as described by Levy and Crawford (2004). These management approaches apply to un-owned FRDC (stray and feral) and include: 1) removal and subsequent adoption, 2) life-long confinement at a sanctuary, and 3) euthanasia vs. Trap-Neuter-Return (TNR).

- *Conflict: Bias*

Another source of conflict apparent in the literature is what appears to be a violation of basic research ethics. While the economic, ecological, emotional, and ethical issues related to the FRDC debate can certainly support strong opinions and biases, such biases must be carefully controlled when designing research. Upon review of FRDC-focused research, it is clear that there are often direct relationships between strongly held beliefs and opinions, and both the design and results of various studies. It seems that many researchers developing and implementing FRDC-related studies are doing so with strong preconceived ideas of anticipated results; that is, agendas are often plainly visible in FRDC-related research design. This likely contributes to the *us vs. them* atmosphere so prevalent in a field of research particularly in need of cooperation.

- *Conflict: Viewpoints*

One of the most significant sources of conflict surrounding the FRDC debate is perhaps derived from the human condition. People form opinions and beliefs based on their viewpoint, which is further built on a multitude of factors including knowledge, experience, and critical thinking skills. While wildlife biologists may tend to hold the view that Trap-Neuter-Release (TNR) is a waste of funds and effort because re-released cats are free to continue hunting, others hold faith in studies that indicate TNR will eventually lead to elimination of those cat populations by attrition (Winter, 2004).

The problem with these and other differing views is that, as previously discussed, they have apparently introduced a large amount of bias and hidden agenda into the knowledge base, which in turn perpetuates stronger opinions and biases. This likely leads to the development of the

aforementioned *us vs. them* mindset, which unfortunately translates into a lack of cooperation among vested parties.

III. Knowledge and Agreement

As discussed in the preceding pages, substantial justification for FRDC-related research is provided by the significant presence of gaps in both knowledge and agreement among involved parties. Throughout the literature various levels of knowledge and agreement exist, and I describe these in terms of *what is known* (what is agreed upon), *what is suspected* (what is mostly agreed upon), and *what is not known* (knowledge gaps).

- *What Is Known*

One subject on which parties tend to be in agreement is that of FRDC impacts on island ecosystems. Islands' isolation and lack of native predators are known to place endemic species at an increased risk of extirpation when exotic species are introduced. For example, according to Winter (2004), cat predation has been attributed to the extirpation of 41 bird species from New Zealand's islands alone. Since many wildlife biologists recognize FRDC as an invasive predator species, it is not surprising that there is generally little debate over their impacts to wildlife in such susceptible ecosystems.

Another subject of general agreement concerns FRDC-related policies toward at-risk wildlife, including those on reserves or other protected public lands. The Wildlife Society's policy on feral and free-ranging cats supports local and state ordinances to prohibit the release of unwanted pet (or feral) cats into the wild, as well as the public feeding of feral cats, especially on public lands (Wildlife Society, 2007). While some disagreement remains regarding the strict prohibition of public feeding of feral cats (over concerns regarding the welfare of existing colonies), the Wildlife Society policy and similar policies are generally agreed upon.

- *What Is Suspected*

A significant portion of research related to FRDC in the United States has focused on disease transmission to humans and other wildlife. While there is some disagreement surrounding the status of *Felis catus* as a reservoir for rabies, the literature generally indicates agreement on the importance of respecting the capacity of feral mammals, including FRDC, to become reservoirs of various transmittable diseases. Suzan & Ceballos (2005) cite various sources when surmising that infectious disease is becoming a significant threat to wildlife in protected areas. One of the more notorious examples they refer to is the near decimation of the Black-Footed Ferret (*Mustela negripes*) by canine distemper.

A few studies have also begun linking habitat loss and fragmentation with various aspects of the FRDC issue. In their study of feral mammals and disease prevalence in Mexico City, Suzan and Ceballos (2005) determined that a high degree of landscape perturbation events is correlated with both high antibody response rate to certain infectious agents in wildlife, and high density of feral animals who carry the diseases and transmit them to native wildlife.

Winter (2004) suggests a link between this type of perturbation and impacts related to FRDC when claiming that an increase in fragmented habitat and associated human development has lead to an increase in cat predation of native birds, and is thus becoming an important factor in bird conservation.

- *What Is Not Known*

Two areas of FRDC research with possibly the most significant knowledge gaps and/or disagreement center on the effects of human subsidization on *Felis catus* hunting behavior (including likely differences in hunting behaviors among the FRDC subpopulations), and the direct effects of FRDC predation on mainland prey populations.

On Hunting Behavior…

Many researchers simply cite Fitzgerald's early work that appears in *The Domestic Cat; the Biology of its Behavior* to suggest that *Felis catus* hunts as an innate, instinctive behavior, and thereby assume that human subsidy bears no impact on predation rates (Turner & Bateson, 1988). Others have collected data that suggest predation rates sharply decline in response to subsidization. Kays and DeWan (2004) cite Crooks and Soule (1999) when arguing that mainland FRDC may be of conservation concern because their highly subsidized populations can have significant impacts on native prey, suggesting yet another interpretation of the relationship between *Felis catus* hunting behavior and human subsidization. However, Kays and DeWan (2004) admit that determining the effects of different types of human care on individual cat hunting behavior has proven difficult, and has yet to be achieved.

Many researchers and professionals acknowledge throughout the literature that little is known, with certainty, about the differences in hunting behavior among the various FRDC subcategories. In addition to the effects of varying levels of human subsidy (which somewhat correspond to the various subcategories), little appears to be known about how landscape characteristics (degree of urbanization, for example), ownership status, and differences between FRDC individuals and colonies affect predation habits. For example, Stoskopf & Nutter (2004) hypothesize that much of the disagreement among published feral cat studies may be the result of variation between colonies. Furthermore, studies are increasingly revealing a lack of understanding of individual FRDC hunting habits and preferences (Ramon et al., 2008).

On Direct Effects…

Although Kays & DeWan's 2004 study suggested that cats' hunting of mostly juveniles and common species may limit FRDC potential to impact prey population size, they also express that priority should be given for future research that not only includes population estimates and

hunting and ranging data from specific types of cats, but also sampling of both cat and prey populations to assess direct effects on prey populations.

IV. Calls For Research

An estimated U.S. cat population of nearly 100 million, approximately 75% of which are outside at least part of the time, results in a clear need to better understand *Felis catus* predation habits and related ecological implications (Kays & DeWan, 2004; Foley et al., 2005). As the intensity of the debate increases, bias becomes more prevalent, and the need for data obtained from objectively designed studies becomes paramount.

Habitat loss and fragmentation may represent a confounding factor in assessing FRDC impacts, but this relationship is only occasionally discussed in the literature. The connection between landscape integrity and FRDC impacts may become increasingly important as development continues to occur at higher rates. Cat population tends to follow human population; consequently, not only does increased development potentially imply larger numbers of FRDC, increased fragmentation in landscapes, and thus potentially increased FRDC impacts on wildlife populations, but it may further serve as breeding ground for an emotionally-driven debate that makes rational solutions more elusive. As human habitation increases, so may the need for civic regulations addressing FRDC and cat ownership. Quantitative data are necessary to provide an unbiased foundation for such decisions. Both Fitzgerald (1990) and Jarvis (1990) have warned against potentially wide-ranging civic regulations without additional data on the hunting habits and ecological impacts of FRDC. Moreover, Stoskopf & Nutter (2004) stress that the determination of FRDC impacts on wildlife will require analysis of carefully collected data. Thus far it is questionable whether or not such data collection has occurred.

THIS PROJECT

The Ohio Wildlife Center (OWC) is located in Dublin, Ohio (Delaware County) near one of the fastest growing suburban areas of the United States (Delaware County, 2009). Dublin has recently begun to address concerns regarding local feral and stray cats and may soon be considering regulatory options (C. George, personal communication, 2009). With hopes of future collaboration with communities and decision-makers on the development of solutions to local FRDC debates, the OWC has recognized the need for objective data collection and analysis. Many methods for studying this issue have been utilized, but repeatability and bias issues abound in the literature. The primary purpose of this study is to bring objective quantitative data to the overall FRDC discussion, while providing the Ohio Wildlife Center with much needed analysis of FRDC impacts on their operations.

Partnering with the OWC, I evaluated the FRDC issue through a combined descriptive data analysis and survey method with the intent of contributing more objective data to the growing foundation of FRDC research. This study seeks answers to the following basic questions:

- *How are local free-roaming domestic cats impacting OWC admissions?*
- *What subcategories are responsible for these impacts?*
- *Do the OWC and other wildlife rehabilitation facilities have the potential to serve as lenses through which free-roaming domestic cat issues can be studied?*

OBJECTIVES

This study evaluates the role of FRDC as introduced predators by analyzing data obtained from a wildlife rehabilitation facility. Overall project goals include the examination of FRDC impacts on both local wildlife and associated rehabilitation facility operations, evaluation of the roaming and ownership status of reported predating cats, and determination of potential

rehabilitators' education/outreach needs in terms of these variables. Ultimately, this project contributes to future studies related to FRDC management, associated wildlife impacts, and resulting wildlife management implications.

Specifically, this study seeks to meet the following objectives: **(1) Examine impacts of domestic cat predation on local wildlife admitted to the Ohio Wildlife Center (2) Evaluate the roaming status and ownership of reported predating cats (3) Assess presenters' basic understanding of the cat-predation events, and willingness to complete a survey (4) Examine geographic trends related to reported predation events (5) Assess broader individual wildlife impacts related to the reported predation events.**

METHODS

Objective 1: *Examine impacts of domestic cat predation on local wildlife admitted to the Ohio Wildlife Center*

Between May and October of 2008, species, age, final disposition, and location of incident (zip-code) were collected from the Ohio Wildlife Center's admission/patient medical records for all incidents related to cat predation.

Objectives 2 & 3: *Evaluate the roaming status and ownership of reported predating cats; assess presenters' basic understanding of the cat-predation events, and their willingness to complete a survey*

During the same study period, a multi-focal survey was administered to good-Samaritans who presented wildlife to the OWC as victims of cat-attacks. Survey responses were analyzed as simple count-data, using Microsoft Excel.

Respondents were asked the following:

1. How did you determine the incident was a cat attack? *(witnessed attack, witnessed cat at scene, cat presented victim, other assumption)*
2. What, if known, is the roaming status of the cat involved? *(feral, stray, inside pet, outside pet, inside/outside pet, or unknown)*
3. To whom does the cat belong? *(myself, my neighbor, the neighborhood, unknown – cat is new to area, unknown – never saw cat before)*

Willingness to complete a survey was measured by assessing presenters' rates of compliance with requested completion of survey.

Objective 4: *Examine geographic trends related to reported predation events*

Zip-code data collected from reported cat-predation events occurring over the study period were analyzed for clustering. Statistical significance of any observed clusters was evaluated to determine possible areas of high predation that may be useful for future studies utilizing more extensive field and survey techniques.

Nearest Neighbor Hierarchical Clustering was used to evaluate clustering of all reported zip-codes, and Moran's I was used to determine clustering significance.

Objective 5: *Assess broader individual wildlife impacts related to the reported predation events*

In an attempt to quantify wildlife impacts associated with reported predation events, respondents were asked to provide numeric and disposition data regarding any un-hatched eggs, other young, or other adults that may have been involved in the reported predation incident, but not presented to the OWC.

Specifically, presenters were asked to provide data on the number of *unhatched eggs*, *newborns or other young*, and *other adults* that:

a. escaped unharmed

b. were brought to the wildlife center

c. were fatally wounded, destroyed, or consumed

d. were taken away by the cat

RESULTS

I. Impacts of cat predation on local wildlife admitted to the OWC

A. Demographics of depredated wildlife - *Species*

OWC received 70% of all its admissions for 2008 within the study period. During the study, 370 cases of wildlife depredated by cat were presented, representing ~12% of all OWC admissions for that period. OWC admits approximately 120 species annually, including 73 (61%) avian species and 26 (22%) mammal species (OWC, personal communication, 2009). The 370 cases occurring in this study were comprised of approximately 38 species, including 27 (71%) avian species, 10 (26%) mammal species, and 1 reptile species. Though not tested for significance, it appears that avian species depredated by cats represent a larger proportion of OWC admissions than overall OWC avian admissions. However, a mammal species, the eastern cottontail rabbit (*Sylvilagus floridanus*) by far showed the highest reported depredation rate.

Avian species represented 45% of all individuals depredated by cats and presented to the OWC, and mammals represented 55% (though the eastern cottontail rabbit alone represented 45%). Table 1 lists all species of wildlife captured by cats and presented to the OWC during the study period. Figure 1 illustrates the distribution of the most commonly captured and presented species.

Table 1. Species captured by free-roaming domestic cats and presented to the Ohio Wildlife Center during the study period.

Species	Number of Individuals
Avian	
American goldfinch	3
American robin	46
barn swallow	1
blue jay	4
brown-headed cowbird	3
cedar waxwing	1
chipping sparrow	2
common grackle	7
eastern screech owl	1
European Starling	9
gray catbird	4
house finch	3
house sparrow	14
house wren	8
mallard duck	5
mourning dove	21
northern cardinal	16
northern mockingbird	1
song sparrow	2
Swainson's thrush	1
unidentified sparrow	2
unidentified wren	1
white-eyed vireo	1
white-throated sparrow	1
winter wren	1
wood duck	2
wood thrush	1
Mammal	
deer mouse	2
eastern chipmunk	13
eastern cottontail rabbit	163
gray squirrel	22
house mouse	2
Norway rat	1
raccoon	1
southern flying squirrel	2
thirteen-lined ground	1
squirrel	1
unidentified vole	1
Reptile	
eastern garter snake	1

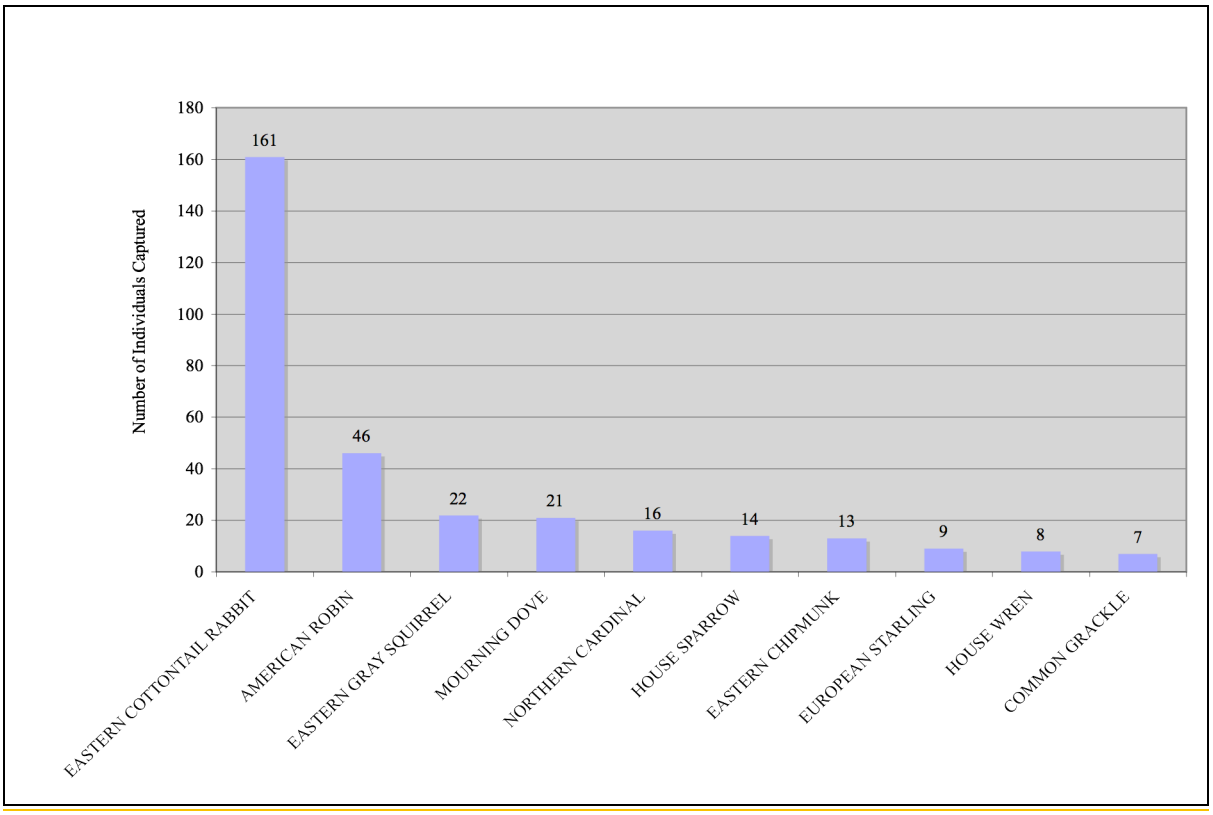

Figure 1. Species most commonly captured by free-roaming domestic cats and presented to the Ohio Wildlife Center, during the study period.

B. Demographics of depredated wildlife – *Age*

Avian and mammal species showed similar trends in rates of capture according to age. Generally, and not surprisingly, young individuals were more likely to be captured and presented to OWC. Avian species were divided into 5 age groups: hatchling, nestling, fledgling, juvenile, and adult. Hatchlings and nestlings represented 36% of the avian individuals presented, fledglings represented 32%, juveniles represented 17%, and adults represented 15%.

Mammal species were divided into 4 age groups: newborn, infant, juvenile, and adult. Newborns and infants represented 57% of all mammals presented, juveniles represented 39%, and adults represented 4%. Figures 2 and 3 illustrate the composition of depredation rates by age of avian and mammal individuals.

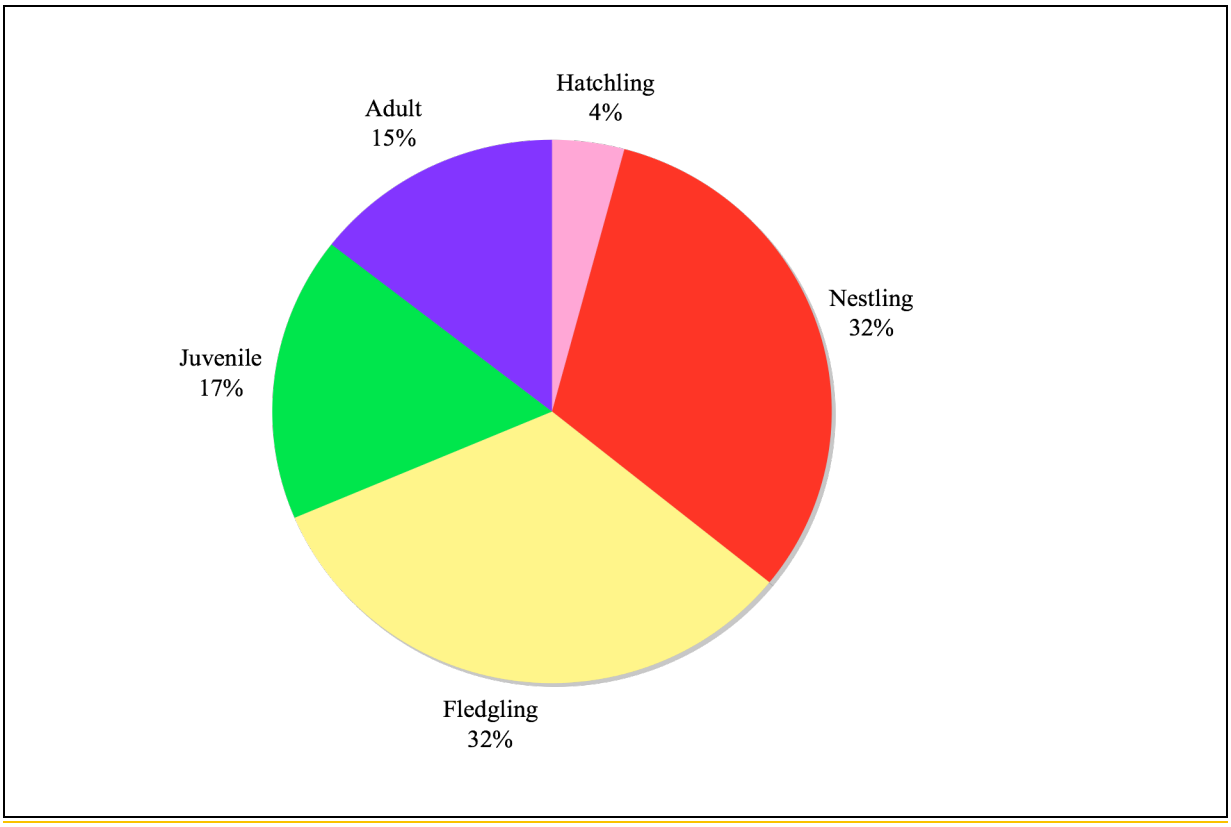

Figure 2. The age distribution of avian species captured by free-roaming domestic cats and presented to the Ohio Wildlife Center during the study period.

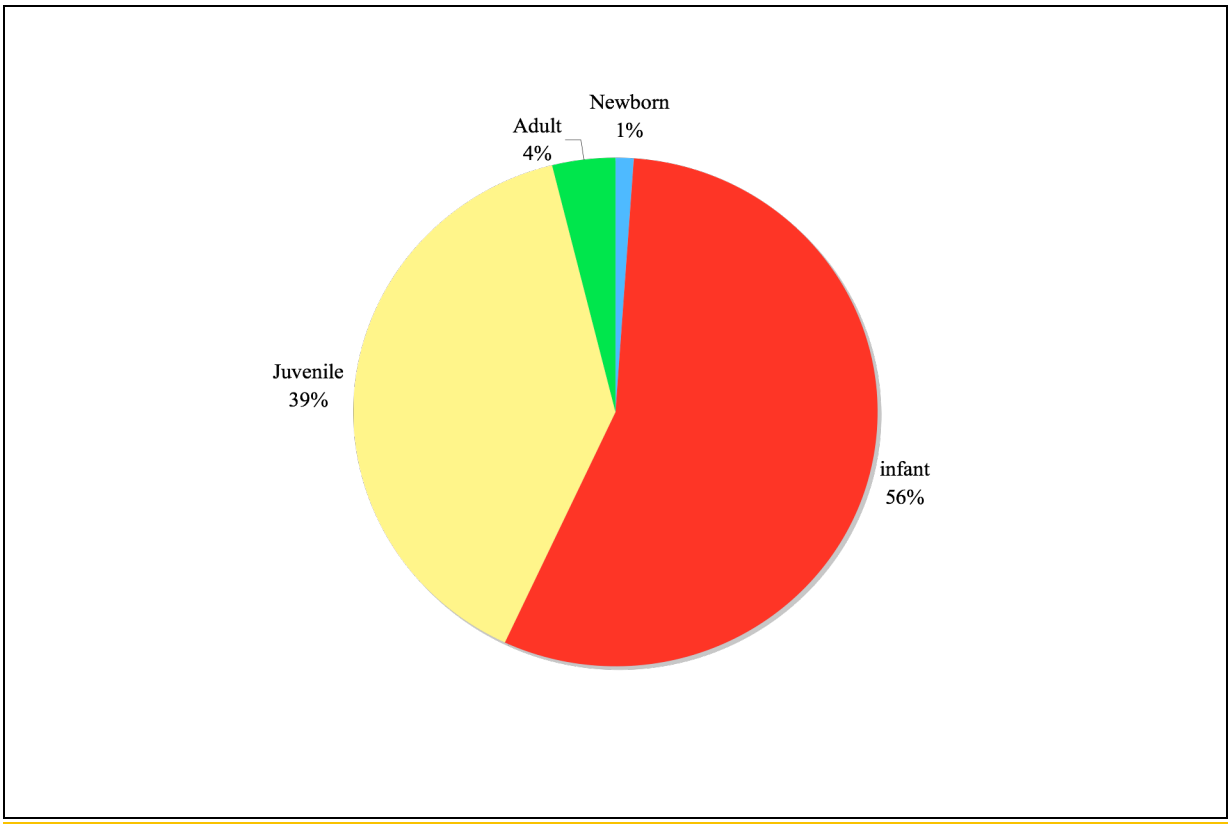

Figure 3. The age distribution of mammal species captured by free-roaming domestic cats and presented to the Ohio Wildlife Center during the study period.

C. Rehabilitation outcomes of depredated wildlife - *Age*

Ignoring hatchlings (due to small sample size), the trend in avian species rehabilitation outcomes according to age indicates a slightly higher survival rate for fledglings and juveniles, and a slightly lower survival rate for nestlings and adults. Ignoring newborns and adults (again, due to small sample size), mammal outcomes indicate a slightly higher survival rate for infants than juveniles.

Disposition rates were calculated by age, and subsequent survival rates *(% of captured individuals that survived and were returned to the ecosystem)* are detailed in table 2.

Table 2. Survival rates (by age class) for avian and mammal individuals captured by free-roaming domestic cats and presented to the Ohio Wildlife Center during the study period.

Species type	**Age class**	**Sample size**	**Survival rate (%)**
Avian			
	Hatchling	7	71[1]
	Nestling	52	17
	Fledgling	54	26
	Juvenile	28	29
	Adult	24	21
Mammal			
	Newborn	2	50[1]
	Infant	114	36
	Juvenile	80	24
	Adult	8	38[1]

[1] Small sample size indicates probable low statistical significance.

D. Rehabilitation outcomes of depredated wildlife – *Species*

The survival rate of all avian individuals presented was 25%, which is lower than OWC's overall survival rate of 31% (OWC, personal communication, 2009). It is unknown if this difference is attributed to species type, age distribution, or reason for admission. The survival rate for mammal individuals was 34%, which is almost equal to, but slightly higher than, OWC's

overall survival rate. Again, the reason for any detected difference in survival rate is unknown. Figure 4 illustrates the distribution of survival rates across mammal and avian individuals.

A binomial distribution process was used to evaluate the difference between rates of outcomes by species type, and tested at the 95% confidence level (p=0.05) to determine significance. The results of this analysis are displayed in table 3. Dispositions represent a continuum of lethality, where "dead on arrival" is indicative of the highest level of lethality, and "released" obviously indicates the lowest level of lethality. For purposes of this analysis, individuals that were transferred to another facility were not included, as their outcomes are unknown.

The statistical analysis indicates that mammals were more likely to receive the highest level of lethal injury, and were thus more likely to die before receiving treatment. There was no significant difference between euthanasia rates among avian and mammal individuals. Avian individuals were more likely to survive depredation injuries long enough to receive treatment, but those injuries were more likely to prove fatal, despite treatment. Finally, mammal individuals who received treatment were more likely to survive and be returned to the ecosystem than treated avian individuals.

Table 3. Rates of outcomes for avian and mammal species captured by free-roaming domestic cats and presented to the Ohio Wildlife Center during the study period. The letter difference indicates a significant difference between avian and mammal individuals for that outcome.

Species type	Died Before Treatment	Died After Treatment	Euthanized	Released
Avian Species	8% A	52% A	15% A	25% A
Mammal Species	10% B	40% B	16% A	34% B

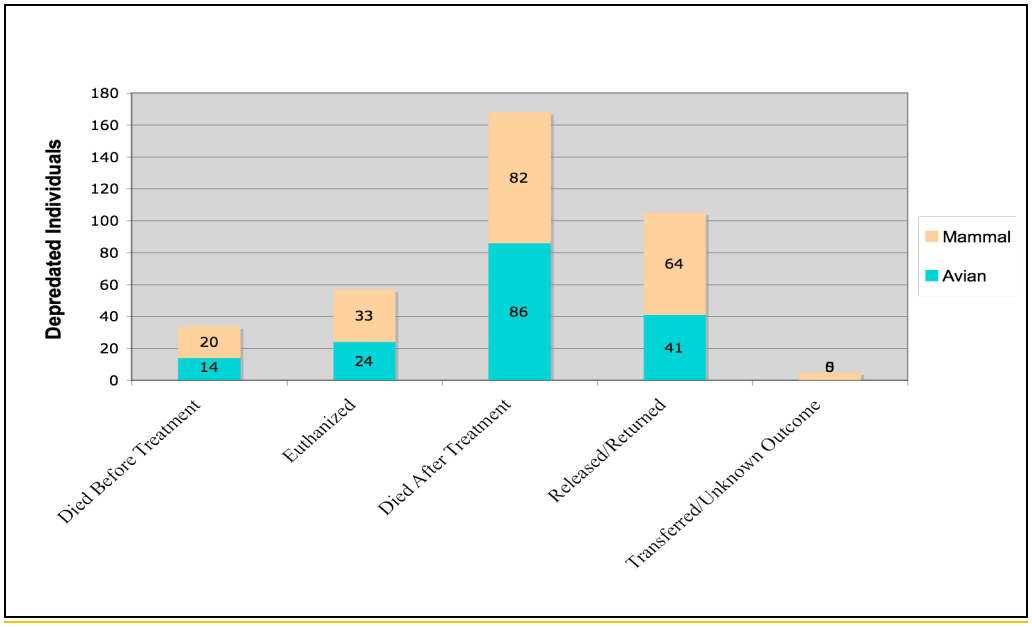

Figure 4. Comparison of outcomes for avian and mammal individuals captured by free-roaming domestic cats and presented to the Ohio Wildlife Center during the study period.

II. Roaming status and ownership of reported predating cats

During the study period, 47 presenters of depredated wildlife completed the survey/questionnaire. For the question assessing roaming status of reported predating cats, 34 out of 47 respondents (72%) indicated that the cat responsible was an inside/outside pet (a.k.a. *IOHC*). Overwhelmingly, the results indicate that, for this sample, the majority of predation is attributed to IOHC. Only 3 predation events were attributed to a feral or stray cat (un-owned FRDC); however, one of those cases is unclear as the respondent further indicated that he/she owned the cat in question. Interestingly, 6 of the reported events were attributed to inside pets, which are not typically a part of the FRDC discussion, while only 1 incident was attributed to an outside pet. Most of the presenters who completed the survey indicated familiarity with the predating cat, as only 6% of the respondents indicated unknown roaming status, and unknown ownership.

Results of the ownership portion of the survey/questionnaire indicate that 53% of the reported predating cats were owned by good-Samaritans who presented injured wildlife to OWC, while 32% were said to belong to a neighbor, and 9% were described as "neighborhood" cats. Overall ownership patterns, according to this survey sample, suggest that approximately 91% of reported predating cats are owned FRDC.

Figure 5 provides a comparative overview of both reported ownership (respondent vs. neighbor) and reported roaming status.

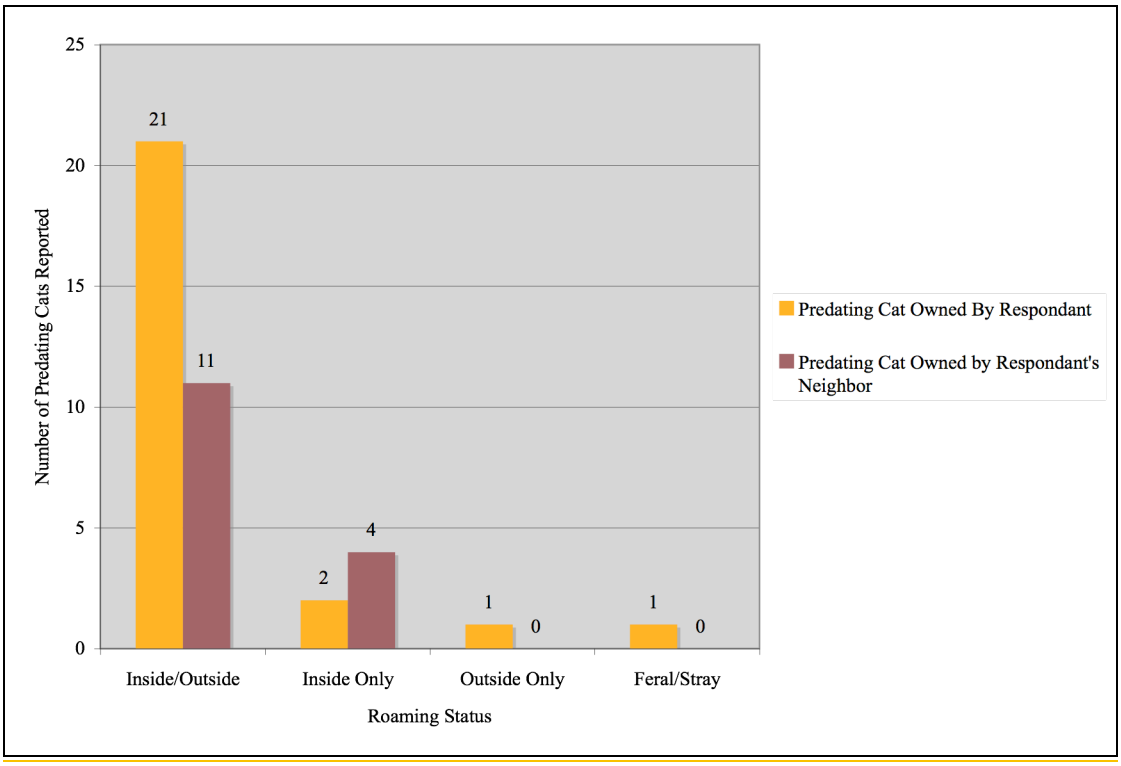

Figure 5. Ownership and roaming status of predating free-roaming domestic cats reported to the Ohio Wildlife Center during the study period.

III. Presenters' basic understanding of the cat-predation events, and willingness to complete a survey

To measure the confidence of the good-Samaritans' awareness that the wildlife they were presenting to OWC were targets of cat predation, the survey asked presenters to indicate how they knew the incident was a cat attack. 40 of the 47 survey respondents (85%) indicated a strong level of confidence that the incident was cat-related by indicating some level of observed cat presence. 53% of the respondents claimed to have "witnessed the attack," 11% assumed the event was a cat-attack based on "witnessing a cat at the scene," and 21% made the assumption because the cat "brought the animal" to the respondent. While 15% of respondents indicated "assumption/other," 6 of those 7 respondents indicated some direct relationship with a cat, giving them reason to assume the incident was cat-related. Reasons cited by respondents who chose this answer include: assumptions based on their cats' past hunting behaviors; evidence such as feathers, fur, blood, etc., found in their home; finding an animal in their home with a cat "about to pounce"; and seeing the cat "running away with the animal in its mouth." All of these reasons suggest a high probability that the incidents were indeed cat-related. Only one of the 47 respondents assumed the incident was cat-related based on a reason not related to some direct experience with a cat; that respondent's assumption was based on the appearance of the wounds.

To assess the potential for utilizing OWC and other rehabilitation facilities for further administration of FRDC-related surveys, the overall rate of compliance was calculated. Of the 367 cat-predation events that occurred during the study period, only 47 surveys were collected, yielding a survey response/compliance rate of 13%.

IV. Geographic trends related to reported predation events

I obtained zip-code data for 367 of the 370 cat-predation events. The data was comprised of 63 Ohio zip-codes, most of which were located throughout the central Ohio region. The zip-code data indicated that the reported predation events occurred in 17 counties. Not surprisingly, Franklin County, where OWC is located, represented the largest number of such incidents. Specifically, incidents from Franklin County represented 73% of all cat predation events reported to OWC. Figure 6 details the geographic distribution of reported incidents by county, and figure 7 illustrates the geographic distribution of reported events within the regions of Franklin County.

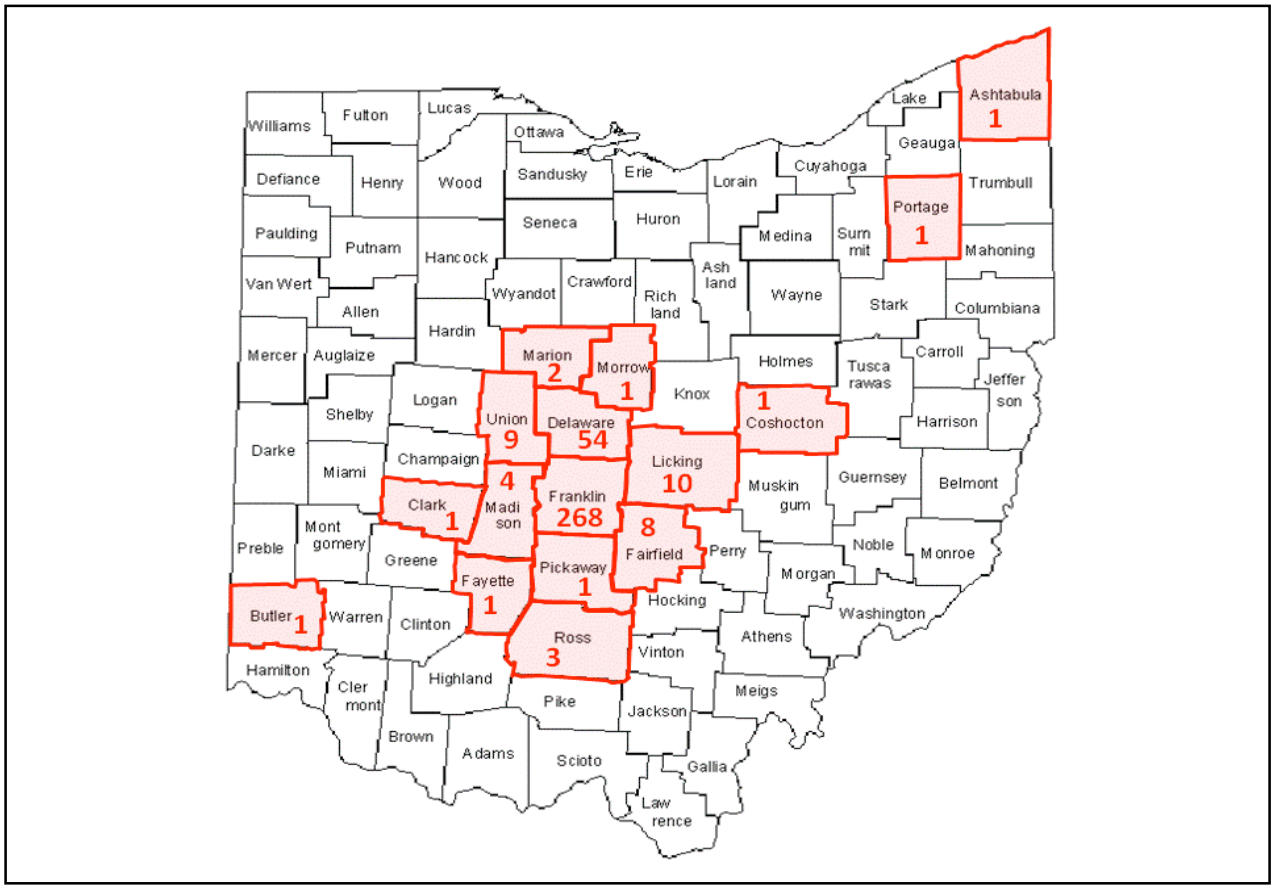

Figure 6. Distribution (by county) of predation events reported to the Ohio Wildlife Center during the study period.

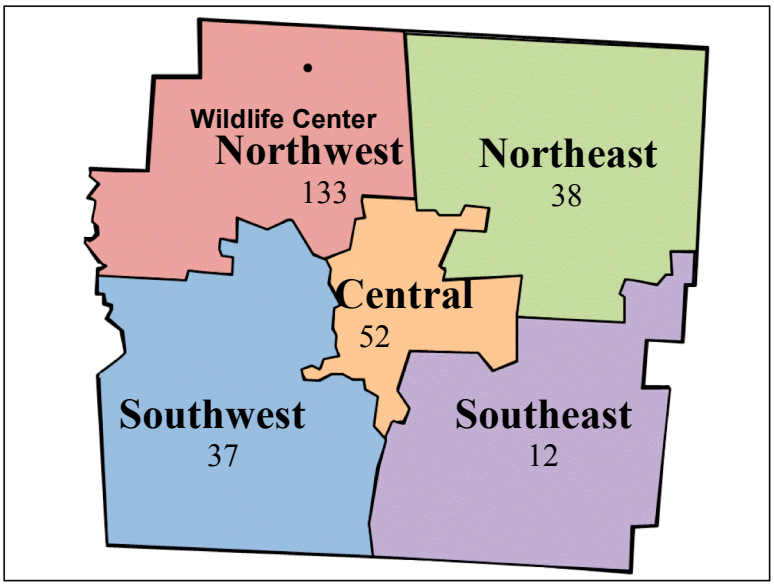

Figure 7. Franklin county distribution of predation events reported to the Ohio Wildlife Center during the study period.

Nearest Neighbor Hierarchical Clustering was used to evaluate possible clustering of all reported zip-codes. The only cluster detected was at zip-code *43235,* which is the zip-code for the location of OWC. This cluster showed extremely high significance, as verified by Moran's I. The geographic statistical analysis is detailed in tables 4 and 5 below.

Table 4. Nearest Neighbor Hierarchical Clustering of the locations of predation events reported to the Ohio Wildlife Center during the study period.

Sample size	63 zip-codes
Likelihood of grouping pair of points by chance	0.50000 (50.000%)
Output units	square miles
Standard Deviations	1.5
Clusters found	1
Mean X,Y (Latitude, Longitude)	40.04379, -83.04318 (zip-code= 43235)

Table 5. Statistical significance (Moran's I) of geographical clustering of predation events reported to the Ohio Wildlife Center during the study period.

Moran's I.....:	0.075910
Spatially random (expected) "I" .....:	-0.016129
Standard deviation of "I" .....:	0.044029
Normality significance (Z) .....:	2.090420
p-value .....:	0.05

V. Assessment of additional local wildlife impacts related to the reported predation events

The final item on the survey/questionnaire addressed otherwise undetectable impacts related to the reported predating events. Unfortunately, this item achieved a somewhat low response rate, and it is unknown if that was due to respondents not observing such impacts, or if such additional impacts did not occur. Of the 47 presenters who completed the survey/questionnaire, 7 (15%) provided the requested numeric data. All 7 responses referred to "newborns or other young," and one included additional data referring to "other adults." According to these responses, 16 additional individual animals were fatally wounded or consumed. When compared to the 370 individuals presented to OWC during the study period, this number appears fairly small (~4% increase in detected impacts). However, when compared to the 47 incidents where presenters complied with survey/questionnaire completion, this number represents approximately a 34% increase in detected impacts.

DISCUSSION

The composition of species captured by FRDC as observed in this study is not surprising. Most of these species have a high likelihood of being encountered by an FRDC, as they either spend a significant amount of time feeding and foraging on the ground, nest on the ground or in

the open, or in the case of many common avian species, such as the American robin (*Turdus migratorius*), may fledge well-before they are able to fly strongly (L. Fosco, personal communication, 2009). The high number of eastern cottontails (*Sylvilagus floridanus*) captured by FRDC can likely be attributed to a number of factors, including high population numbers, large litter size, and nest placement (the ground-scrape nests are commonly placed in the middle of suburban yards). Furthermore, while it is unknown precisely what role species' abundance plays in cat-predation rates, it is likely, as observed in this data, that the most common species are most likely to be captured by FRDC.

Mammalian individuals, while less likely to receive treatment at OWC, are more likely to have a successful outcome when they do. Avian individuals, while more likely to receive treatment, are less likely to have a successful outcome. These differences may be attributed to the fact that mammals are more likely to sustain immediate injury as contact during predation incidents is not dampened by feathers, as opposed to avian individuals who have feathers which provide some protection from lethal crushing, punctures, and lacerations, but nonetheless, are likely to develop fatal bacterial infections in the wounds they do sustain (L. Fosco, personal communication, 2009).

The observed slightly higher survival rate for fledglings and juveniles, and slightly lower survival rate for nestlings and adults may also be attributed to feathers. Unlike nestlings, fledglings and juveniles have feathers, possibly providing them some protection from the predation events. Adults, one could assume, may be more likely to be captured if in a weakened state which would impact their overall likelihood of survival.

Observed mammal outcomes indicate a slightly higher survival rate for infants than juveniles. This is unexpected given infants' fragile skin and lack of fur, and is counter to the aforementioned theory; however, evaluating the avian and mammal sample as a whole, the

apparent relationship between prey's skin exposure and the potential lethality of cat-predation becomes clearer. The total sample indicates that young individuals of both avian and mammal species are most likely to be captured; however, captured avian young tend to have more developed skin covering. While 67% of avian and 96% of mammal individuals captured represented the youngest age categories (non-adult), 63% of captured avian individuals had feathers capable of protecting the skin (fledglings, juvenile, adults), while only 24% of the captured mammal individuals had fur. The high rate of initial lethality of depredated mammals, combined with the high capture rate of mammals with little or no fur, seems to give this theory some merit, despite the unexpected values for juvenile and infant survival.

The data obtained regarding ownership and roaming status suggests that the majority of predation incidents reported to OWC are related to owned FRDC, and moreover, FRDC owned by the good-Samaritans presenting depredated wildlife for rehabilitation. Though only 13% of presenters completed the survey, the observed ownership pattern provokes interesting questions about the relationships between cat owners' likelihood of finding and/or attempting to rescue wildlife, and their willingness to provide information regarding predation events.

The survey compliance rate of 13% is lower than other FRDC survey methods, so wildlife rehabilitation facilities may not provide a suitable survey sample for future FRDC studies (Baker, Bentley, Ansell, & Harris, 2005; Ramon, Slater, Ward & Lopez, 2008).

The intensity of the single cluster observed in the geographic information indicates that using location of incident data from incidents reported to a wildlife facility may not be useful in future studies seeking to determine patterns or clusters of predation, since reporting appears to be highly correlated with distance to the facility.

Although the overall survey compliance rate was low, and furthermore, the response rate to requested data about other individuals involved in the incident, but not presented to the facility,

was low as well (15%), the associated data obtained may warrant further investigation and use of this technique. Although statistical significance was not determined, the 34% increase in detected impacts appears potentially significant.

CONCLUSIONS AND RECOMMENDATIONS

The overall survival rate for wildlife captured by FRDC and presented to the Ohio Wildlife Center appears to be slightly lower than the survival rate of all injured wildlife presented, making cat predation a significant concern for the facility.

Of the presenters who completed the survey, nearly 45% owned the predating cat, and nearly 72% of reported cats were inside/outside house cats (IOHC). Given the mission of the Ohio Wildlife Center of promoting both wellness of local wildlife and education of the public, the facility may want to consider launching an education and awareness campaign regarding the concerns related to FRDC. The American Bird Conservancy's program "Cats Indoors!" might be a viable means for OWC to address this concern, as they have educational materials available for use by organizations wishing to implement such a campaign (American Bird Conservancy, 2009). Furthermore, OWC should continue to partner with researchers seeking ways to fairly evaluate this issue, as the organization has the potential to play a significant role in the development of local FRDC regulations.

The scope of this study is limited to impacts on wildlife that have been *found* by an individual, and found by an individual who is both *aware* of OWC and its services, and *willing and able* to present the depredated animal to the facility. Accordingly, the sample represented in this study likely under-reports the incidents of FRDC predation. Therefore, the 370 cat-predation incidents that occurred in the 5-month study period (approximately 2.5 incidents/day) may be indicative of a more significant amount of predation.

Much of the FRDC debate now centers on the two polarized views that (1) impacts of predation have been grossly exaggerated and are merely distracting researchers from more serious threats, and (2) the number of wildlife deaths by FRDC predation must be having some sort of impact (Lilith, Calver, Styles, & Garkaklis, 2006). Perhaps, however, it is time to begin seeking middle ground. One way to approach this may be to better define *impacts*, and determine what *types and levels of impact are acceptable*. Clearly, FRDC are affecting wildlife in Franklin County, but the species most commonly captured also appear to be the species most abundant in the urbanized ecosystem. Some may contend that this fact lessens the importance of FRDC impacts to such urbanized areas. Much like agendas, perceptions of FRDC impacts are directly related to stakeholders' interests. For an organization like OWC, these impacts are quite significant, as their interests lie in the protection of all local wildlife species, not just those that are threatened, endangered, or of special concern. For wildlife agencies with limited resources, however, concern for FRDC impacts may necessarily be limited to those affecting only the most vulnerable populations. Stakeholders must reach some sort of agreement on what constitutes significant impacts, before studies can be fairly and effectively analyzed and applied to the development and implementation of FRDC policy.

That said, a need for well-designed studies to assess FRDC impacts remains. Future studies utilizing wildlife rehabilitation facilities should include strategies to improve survey compliance, as it appears that those who present wildlife depredated by cats are willing to provide data when their cat is responsible. This may further indicate a willingness of such cat owners to participate in more in-depth surveying or other investigative techniques such as radio-collaring and subsequent behavior observation of FRDC. Furthermore, if survey compliance were improved, it may be possible to obtain a broader picture of local impacts related to reported predation events by obtaining data regarding other individuals involved, but not presented for treatment.

In addition to improving survey compliance, future FRDC studies monitoring wildlife rehabilitation admissions will benefit by simultaneously monitoring a focal species throughout the geographic range corresponding to reported incidents. This would provide researchers a source of comparison vital to determining population-level impacts, as well as a platform for evaluating the additive/compensatory effects of FRDC on wildlife mortality. Likewise, future studies should focus on a variety of local landscapes in addition to a focal species, thereby assessing the relationship between urbanization and FRDC impacts on wildlife. Such studies should also include the determination of associated cat densities to assess the relationship between urbanization, population-level impacts, and FRDC cat density. Finally, future FRDC studies utilizing similar wildlife center based data-collection techniques should attempt to determine the relationship between cat ownership and the likelihood of presenting injured wildlife for rehabilitation. This is necessary to evaluate the accuracy of ownership patterns observed in this study, which suggest that the FRDC sub-category responsible for the majority of predation is also the most highly subsidized – the inside/outside house cat. This should be further evaluated because current FRDC research in the United States tends to focus on stray and feral cats. If the majority of impacts to wildlife are truly caused by pets, an increase in social science studies will be essential to improving our understanding of, and reaching feasible solutions to, this highly complex issue.

Acknowledgements:

This project was made possible by the support and cooperation of Dr. Donald Burton, Lisa Fosco, and staff and volunteers of the Ohio Wildlife Center. Furthermore, I thank the numerous good-Samaritans who continue to present injured wildlife to the OWC, and those who took the time to complete this study's survey. I am ever grateful to my advisor, Dr. Roger Williams, for introducing me to Dr. Burton, his assistance with data analysis, and for his continual encouragement that I would indeed "get it done." Additionally, I would like to express my gratitude to Dr. James Christensen for his time spent assisting me with geostatistical analysis, and Dr. Gregory Hitzhusen for thoughtful discussion regarding approaching the synthesis of my information. Lastly, I thank my committee-members, Dr. Jeremy Bruskotter and Dr. Paul Rodewald, for setting aside time in their busy schedules to consult with me on this project.

References

American Pet Products manufacturing Association (2002). *2001-2002 national pet owner survey*. Greenwich, CT.

Baker, P.B., Bentley, A.J., Ansell, R.J., Harris, S. (2005). Impact of predation by domestic cats *Felis catus* in an urban area [Electronic version]. *Mammal Review, 35*, 302-312.

Crooks, D.R., Soule, M.E. (1999). Mesopredator release and avifaunal extinctions in a fragmented system [Electronic version]. *Nature, 400*, 563-566.

Delaware County. *Delaware County Ohio USA*. Retrieved May 15, 2009, from http://www.co.delaware.oh.us/.webloc

Foley, P., Foley, J.E., Levy, J.K, Paik, T. (2005). Analysis of the impact of trap-neuter-return programs on populations of feral cats [Electronic version]. *JAVMA, 227*, 1775-1781.

Jarvis, P.J. (1990). Urban cats as pests and pets [Electronic version]. *Environmental Conservation, 19*, 169-171.

Kays, R.W., DeWan, A.A. (2004). Ecological impact of inside/outside house cats around a suburban nature preserve [Electronic version]. *Animal Conservation, 7*, 273-283.

Lillith, M., Calver, M., Styles, I., Garkaklis, M. (2006). Protecting wildlife from predation by owned domestic cats: Application of a precautionary approach to the acceptability of proposed regulations. *Austral Ecology, 31*, 176-189.

Levy, J.K., Crawford, P.C. (2004). Humane strategies for controlling feral cat populations [Electronic version]. *JAVMA. 225*, 1354-1360.

Ohio Wildlife Center. *Our mission*. Retrieved May 15, 2009, from http:www.ohiowildlifecenter.org

Ramon, M.E., Slater, M.R., Ward, M.P., Lopez, R.R. (2008). Repeatability of a telephone questionnaire on cat-ownership patterns and pet-owner demographics evaluation in a community in Texas, USA [Electronic version]. *Preventative Veterinary Medicine, 85*, 25-33.

Slater, M.R. (2004). Understanding issues and solutions for unowned, free-roaming cat populations [Electronic version]. *JAVMA, 225,* 1350-1354.

Stoskopf, M.K., Nutter, F.B. (2004). Analyzing approaches to feral cat management – one size does not fit all [Electronic version]. *JAVMA, 225*, 1361-1364.

Suzan, G., Ceballos, G. (2005). The role of feral mammals on wildlife infectious disease prevalence in two nature reserves within Mexico City limits [Electronic version]. *Journal of Zoo and Wildlife Medicine, 36*, 479-485.

The Wildlife Society. *Policy 25: feral and free-roaming cats*. Retrieved February 14, 2007 from www.wildlife.org

Turner, D.C., Bateson, P. (Eds.). (1988). *The domestic cat: the biology of its behavior.* Cambridge: Cambridge University Press.

Winter, L. (2004). Trap-Neuter-Release programs: the reality and the impacts [Electronic version]. *JAVMA, 225,* 1369-1372.